CO observations of southern mergers

F. Casoli, C. Dupraz, F. Combes

Radioastronomie, Ecole normale supérieure
24, rue Lhomond, F-75231 Paris Cedex 05, France

1. Introduction

There are good reasons to believe that the formation of some elliptical galaxies result from the merging of two disk galaxies, as Toomre and Toomre first suggested (1972, *Ap. J.* **178**, 623). Such a process strongly enhances the star-formation activity of the system, thus consuming its molecular gas. This might account for the low cold-gas content of elliptical galaxies compared to that of spirals. We present here CO(1-0) and CO(2-1) observations of a sequence of three objects, NGC 1614, NGC 3256, and NGC 7252, that present characteristic features of merger remnants: single body and extended tidal tails. NGC 3256 and 7252 even exhibit the $r^{1/4}$ radial light distribution that is the signature of elliptical galaxies, which indicates that their stellar bodies are in late stages of relaxation.

Both NGC 1614 and NGC 3256 undergo extended bursts of star formation revealed by their large far-infrared luminosities, and by the presence in the near-infrared spectrum of the 3.28 μm feature (Morwood: 1986, *A. A.* **166**, 4) attributed to polycyclic aromatic hydrocarbons. On the other hand, NGC 7252 has a milder activity of star formation, as suggested by a lower infrared luminosity, and thus seems to have gone past the starburst phase.

2. Observations

The CO data were collected with the Swedish-ESO 15 m Submillimeter Telescope (SEST) (beamsize = 43" at 115 GHz, 23" at 230 GHz). For NGC 7252, we have only observed the central position in ^{12}CO(1-0). The spectrum is displayed on Figure 1 together with an HI spectrum obtained with the Nancay radiotelescope. We have mapped NGC 1614 and NGC 3256 in ^{12}CO(1-0) and ^{12}CO(2-1), and also observed the nucleus of NGC 3256 in ^{13}CO(1-0). The various CO spectra obtained towards the nuclei of both galaxies are presented in Figure 3. Characteristics of the galaxies are gathered below, with luminosities and masses in solar units and temperatures in Kelvins.

Name	L_{IR}	L_B	$M(H_2)$	L_{IR}/L_B	$L_{IR}/M(H_2)$	$T_{60/100}$
NGC 1614	$2.7\ 10^{11}$	$2.5\ 10^{10}$	$6.7\ 10^{9}$	11	40	52
NGC 3256	$2.4\ 10^{11}$	$4.5\ 10^{10}$	$16.2\ 10^{10}$	5	19	45
NGC 7252	$3.9\ 10^{10}$	$4.7\ 10^{10}$	$4.2\ 10^{9}$	0.8	9	38

3. Results and discussion

• The CO(1-0) emission of NGC 1614 and NGC 3256 is barely resolved by the 43" beam. In both objects, its full width at half maximum is about 7 kpc, after deconvolution of the beam. In NGC 7252, the CO emission is likely diluted in the beam (Dupraz *et al.*: 1989, submitted to *A. A.*).

• Using a conversion factor of 2.3 10^{20} cm^{-2} $(K\ km\ s^{-1})^{-1}$ from $^{12}CO(1-0)$ emissivities to $N(H_2)$ column densities, we derive molecular masses of $M(H_2)$ = 6.7 10^9, 1.6 10^{10} and 3.6 10^9 M_o for NGC 1614, 3256 and 7252 respectively [NGC 7252 also contains 3.4 10^9 M_o of atomic gas].

• In NGC 1614 and NGC 3256, the ratio of CO(2-1) to CO(1-0) integrated emissivities is about 1.2, in the main-beam temperature scale. This indicates that the molecular gas is not predominantly optically thin. In NGC 3256, the $^{13}CO(1-0)$ line is about 30 times weaker than the $^{12}CO(1-0)$ line, which suggests that the CO emission is not very optically thick either. Although definite conclusions cannot be drawn from such large scale observations, this situation appears intermediate between that of most spirals, where the $^{12}CO(1-0)$ optical depth is large, and that of starburst nuclei like M82's where it is smaller than one. Accordingly, the molecular masses derived above, by use of the standard conversion factor, may be somewhat overestimated.

• NGC 1614 and NGC 3256 are very actively star-forming mergers. Such objects are known to possess large amounts of molecular material. NGC 7252 is a more intriguing object, for this rather old merger remnant no longer experiences a starburst, and yet is still gas-rich. This shows that, at least in some cases, the star burst is unable to exhaust all of the molecular gas of the system, and that long-term processes, such as an activity of star formation typical of spiral galaxies, are required if the merger remnant is to become a normal elliptical galaxy, nearly devoid of cold gas.

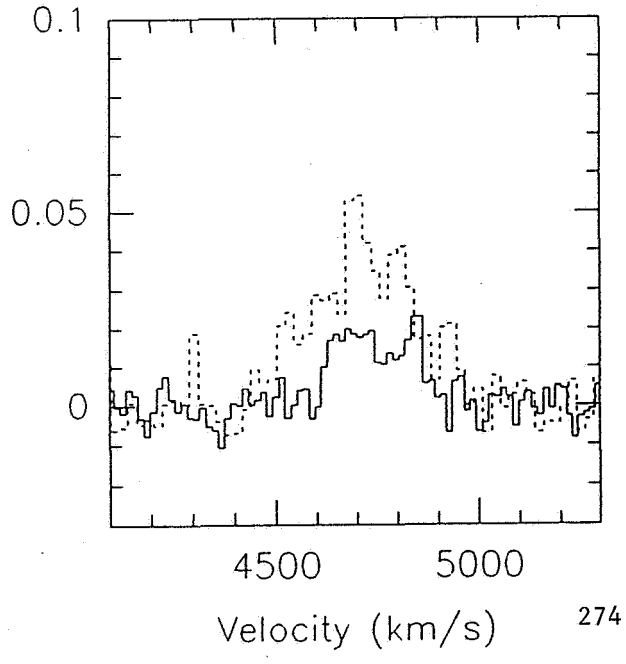

Figure 1: $^{12}CO(1-0)$ and HI spectra of NGC 7252; temperature scale is T_R^*.

Figure 2: *left:* isocontours of ^{12}CO(1-0) integrated emissivity for NGC 1614, levels are 1.5 (1.5) 7.5 K km s^{-1}; *right:* same for NGC 3256, levels are 2.5 (5) 47.5 K km s^{-1}.

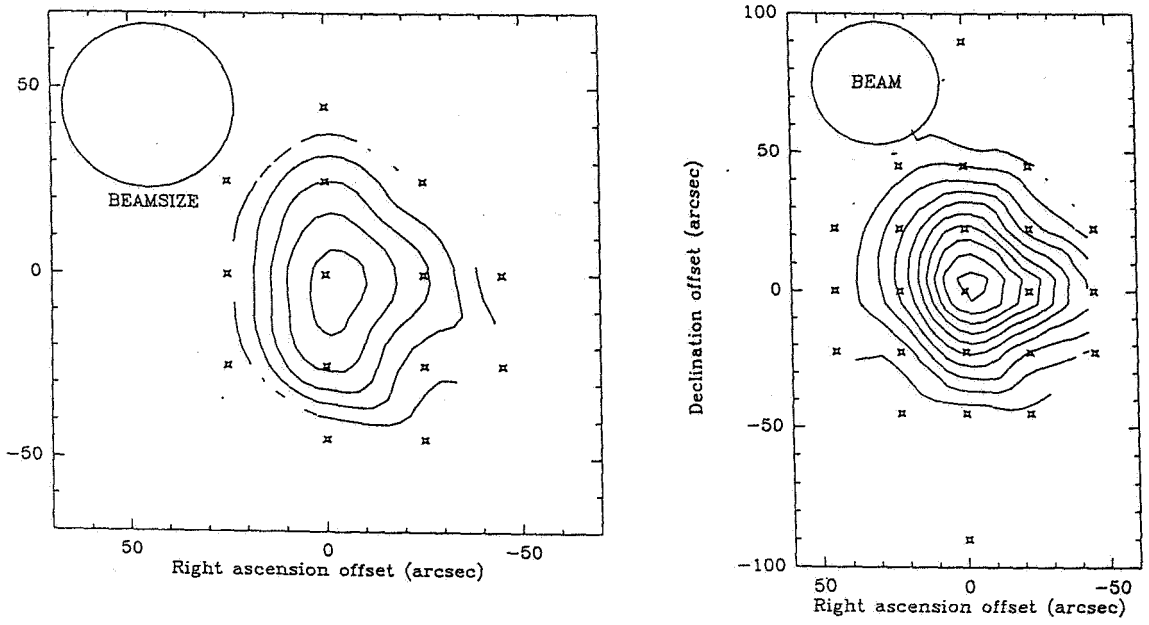

Figure 3: *left:* central ^{12}CO(1-0) and ^{12}CO(2-1) spectra of NGC 1614; *right:* same for NGC 3256, together with the ^{13}CO(1-0) spectrum multiplied by 10.